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Interpretation of VLBI Results in Geodesy,
Astrometry and Geophysics

Astrometry from VLBA Observations at 24 and 43 GHz

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Abstract. Astrometric results are obtained from a collaboration formed to study extragalactic objects at radio frequencies between 20 and 50 GHz: The K-Q VLBI Survey Collaboration. We analyzed ten 24-hour observing sessions at the VLBA interferometer over a 5-year period, including nearly three hundred radio sources. Our analysis indicates reduction in source structure effects on source positions relative to X-band observations. The median formal uncertainties of right ascension and declination are 0.08 and 0.15 milliarcseconds, and the average absolute difference between the K-band (24 GHz) and the S-X estimated source positions are 0.17 and 0.23 milliarseconds, respectively. These differences are partly due to absent or inadequate modeling of physical effects.

1. Goals

Early in this decade, we formed the K-Q VLBI Survey Collaboration in order to extend radio-based celestial reference frames above 8 GHz (X-band). Our goals were:

- Enabling Deep Space Navigation at 32 GHz (Ka band).
  - This requires radio source positions above X band.
  - This requires source structure information.

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- Improving reference source positions above X-band.

The VLBA had the imaging capability and it allowed us efficiently to

- observe at enveloping frequencies of 24 and 43 GHz.
- obtain radio source catalogs at these enveloping frequencies.

It was important to obtain source structure information from imaging in order to assess the compactness of the sources and thus their suitability for high accuracy work.

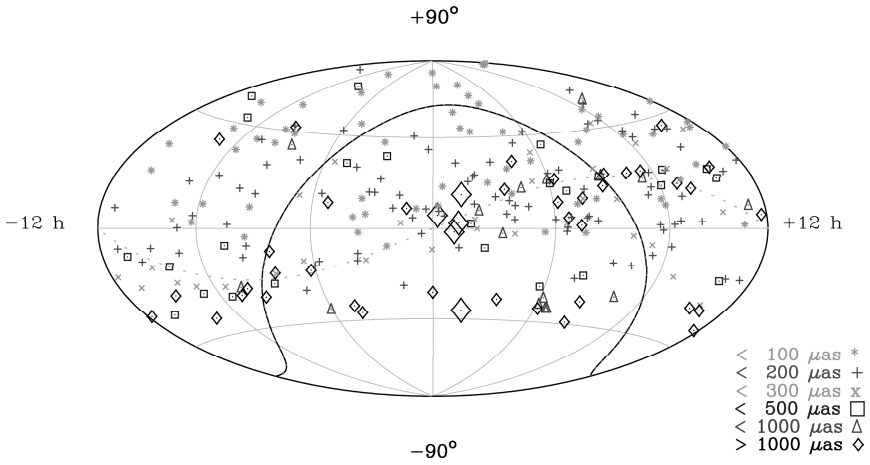

Figure 1. Distribution of 275 K-band sources. Symbols indicate 1-σ formal declination uncertainties with size bins according to legend at lower right. $(\alpha, \delta) = (0, 0)$ is at the center. The ecliptic plane is indicated by a dashed line. The galactic plane is indicated as a black line approximating the shape of Ω

2. Results

We observed by the VLBA on 10 different dates starting in May 2002 and most recently in Mar. 2007. Each session was approximately 24 hours in duration and contained multiple snapshots per source in order to allow imaging. We obtained:

- 275 source positions and images at 24 GHz (K band).
- 132 source positions and images at 43 GHz (Q band).
- Reduced source structure K vs. X.
- Reduced position error due to source structure.
- Formal position uncertainty at the 0.17 mas level at K-band.

Fig. 1 shows the distribution of K-band sources. Q-band's reduced sensitivity relative to K-band coupled with the smaller number of sessions resulted in a smaller catalog of 132 sources.

3. Source Structure Effects

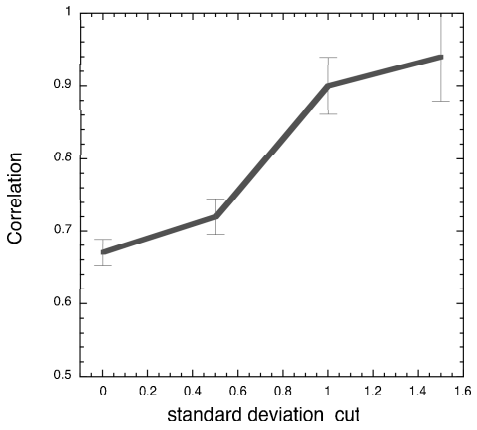

Figure 2. Astrometry vs. Image based source structure magnitude correlation. Correlation between differential R.A. and structure delay. Structure effect becomes significant above noise level. Left to Right: Sources are removed below specified error level

Our analysis shows that source structure was reduced at K vs. X-band thus reducing position error due to structure (see Charlot, this volume for further details). To exhibit the connection between the image based structure contribution to source positions and the astrometric position measurement, we performed:

- imaging: Estimation of structure induced position displacements,
- astrometry: Calculation of absolute differences between K and X-band coordinates,
- correlation coefficients between the above two quantities including all overlapping sources,
- coefficients are grouped according to lower bounds on positional error.

Fig. 2 shows this average correlation coefficient starting with all data and then for data sets that required the position shifts to be greater than thresholds of 0.5, 1.0, and 1.5 standard deviation. The plot shows that the structure induced shifts become more significant above the noise level, as expected. This trend gives us confidence that imaging considerations and astrometry are in agreement.

4. Conclusions

The K-Q VLBI Survey Collaboration has completed 10 survey experiments using the VLBA resulting in astrometric catalogs and imaging for 275 objects at K-band and 132 objects at Q-band. Both astrometry and imaging data are in agreement that sources become more compact at K-band than at X-band. The obtained catalogs and imaging data will be useful for high accuracy navigation and phase reference astrometry.

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References

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